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NATIONAL DAM SAFETY PROGRAM. DREXEL LAKE DAM (MO 20046), OSAGE --ETC(U)
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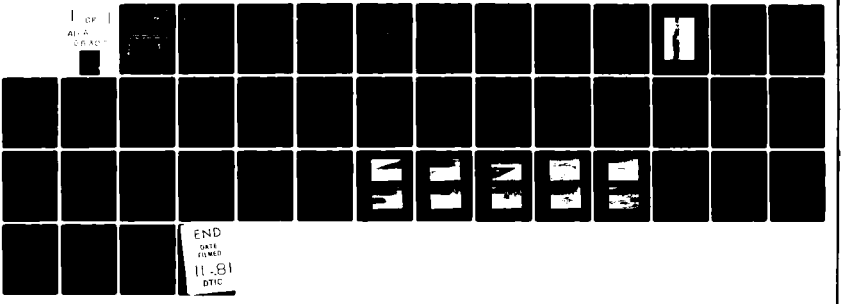

OSAGE-GASCONADE BASIN

AD A106300

LEVEL II

DREXEL LAKE DAM

BATES COUNTY, MISSOURI

MO 20046

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

APRIL 1979

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1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A106 300 / 3. RECIPIENT'S CATALOG NUMBER
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.	

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OSAGE-GASCONADE BASIN

DREXEL LAKE DAM

BATES COUNTY, MISSOURI

MO 20046

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

APRIL 1979

DREXEL LAKE DAM

BATES COUNTY, MISSOURI

MISSOURI INVENTORY NO. 20046

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

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BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

APRIL 1979

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Drexel Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Drexel Lake Dam:

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood
2) Overtopping could result in dam failure
3) Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED
Chief, Engineering Division

30 JUL 1979
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

30 JUL 1979
Date

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Drexel Lake Dam
State Located	Missouri
County Located	Bates County
Stream	North Sugar Creek
Date of Inspection	5 April 1979

Drexel Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers failure would threaten the life and property of approximately four families and would potentially cause appreciable damage to the water treatment plant for the City of Drexel within the estimated damage zone which extends 0.5 miles downstream of the dam.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass the probable maximum flood without overtopping but will pass 20 percent of the probable maximum flood, which is greater than the calculated 100-year flood. The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the size of the dam and reservoir and the downstream hazard potential, the appropriate spillway design capacity for this dam should be 50 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Seepage and stability analyses required by the guidelines were not available. Detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report on the dam is attached.

Paul R. Zaman, PE
Illinois 62-29261

Les K. Lampe, PE
Kansas 7407

Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DREXEL LAKE DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Drexel Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) Drexel Dam is an earth structure located on North Sugar Creek in northwestern Bates County, Missouri (Plate 1). The dam is 460 feet long and forms a 26-acre water supply and fishing lake. The structure is well maintained with rock riprap on both the upstream and downstream faces. The spillway is located at the left abutment, and the water intake to the treatment plant is near the middle of the dam. The watershed is primarily comprised of crop and grass land. Topography of the contributing watershed is characterized by flat lands to gently rolling hills. Topography in the vicinity of the dam is shown on Plate 2.

(2) The spillway is located at the left abutment of the dam. It consists of a concrete overflow weir, a concrete wall along the left abutment of the dam, and a discharge channel consisting of natural earth, broken shale, and limestone. The side slopes of the channel are moderately tree covered.

(3) An intake structure for the water treatment plant is located in the dam about 130 feet north of the south abutment. The structure is a square concrete tower with multilevel inlets. Reportedly a 3-inch diameter pipe goes from the intake structure, through the dam, to the water treatment plant located near the downstream face at the north end of the dam.

(4) Water is pumped into Drexel Lake from another lake located approximately 3/4 mile south of the dam. The 6-inch diameter inflow pipe is located approximately 150 feet north of the south abutment.

(5) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in northwestern Bates County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Drexel, Missouri, in Section 6 of T42N, R33W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Drexel Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Drexel Lake Dam the flood damage zone extends downstream for 0.5 mile. Within the damage zone are four homes and the water treatment plant for the City of Drexel.

e. Ownership. The dam is owned by the City of Drexel. Information can be obtained from City Hall, Drexel, Missouri 64742.

f. Purpose of Dam. The dam forms a 26-acre lake for water supply and fishing.

g. Design and Construction History. Data relating to the design and construction were not available. The dam was built in 1953.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, withdrawals to the water treatment plant, and outflow through the spillway all combine to maintain a relatively stable water surface elevation. During periods of little or no rainfall and heavy water usage, water is pumped into Drexel Lake from a lake located south of Drexel to maintain the pool level for water supply and recreational uses.

1.3 PERTINENT DATA

a. Drainage Area - 2,920 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled spillway.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation 3,480 cfs (top of dam El.972.8).

c. Elevation (Feet Above M.S.L.).

(1) Top of dam - 972.8 ± (see Plate 3)

(2) Spillway crest - 965.0

(3) Streambed at toe of dam - 950.0 ±

(4) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 4,700 feet ±

(2) Length of normal pool - 3,200 feet ±

e. Storage (Acre-feet).

(1) Top of dam - 502

(2) Spillway crest - 112 (from 1974 inventory)

(3) Design surcharge - Not available.

f. Reservoir Surface (Acres).

(1) Top of dam - 88

(2) Spillway crest - 26

g. Dam.

(1) Type - Earth embankment

(2) Length - 460 feet

(3) Height - 17 feet ±

(4) Top width - 9 feet

(5) Side slopes - upstream face 1.0 V to 2.5 H, downstream face 1.0 V to 2.8 H (see Plate 4)

(6) Zoning - Unknown.

(7) Impervious core - Unknown.

(8) Cutoff - Unknown.

(9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Spillway.

(1) Type - Concrete weir with natural earth, shale, and limestone channel.

(2) Width of channel - 50 to 60 feet, varies.

(3) Crest elevation - 965.0 feet m.s.l.

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - Open channel comprised of natural earth, broken limestone, and shale located on the left end of the embankment.

j. Regulating Outlets - The intake structure and 3-inch diameter pipe to the treatment plant could be used to drawdown the lake. The small diameter of the pipe would necessitate a long drawdown time.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were unavailable.

2.2 CONSTRUCTION

Construction records were unavailable, however, the owners stated that the dam was built in 1953.

2.3 OPERATION

The maximum recorded loading on the dam is unknown.

2.4 EVALUATION

a. Availability. No engineering data could be obtained.

b. Adequacy. No engineering data were available upon which to make a detailed assessment of the design, construction, and operation. Detailed seepage and stability analyses should be performed as required by the guidelines.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

2.5 GEOLOGY

The dam is located in a valley formed in limestones and shales of the Pennsylvanian System, Marmaton Group. These are overlain by the Summit Silt Loam soil series, a residual clayey silt and silty clay soil varying in thickness from 0 to 5 feet. The foundation and abutments of the dam are anticipated to be shale and limestone overlain by silty clay. Limestone and shale are exposed in the spillway channel and downstream channel below the spillway. The bedding is horizontal and thin with closed bedding planes and a few widely spaced, closed, vertical joints.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Drexel Lake Dam was made on 5 April 1979. The inspection team included professional engineers with experience in dam design and construction, hydrologic - hydraulic engineering, and geotechnical engineering. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following items at the dam. There was no observable erosion of either the upstream or downstream slope of the embankment. The limestone riprap on both slopes is in good condition. The dam is well maintained. Brush is regularly removed from the embankment and the grass cover beyond the riprap on the downstream slope of the embankment is mowed regularly. No sloughing or seepage was observed on the downstream embankment. No settlement of the embankment was noticed, nor were any significant animal burrows present in the embankment.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The spillway constructed at the left abutment of the embankment appears to be in good condition. The spillway has a concrete sill at the upstream end which serves as a broad-crested weir. The base of the spillway is unlined and is broken shale and limestone. The right wall of the spillway is a concrete wall 5 feet high, extending approximately 80 feet along the right side of the spillway discharge channel. The left side of the spillway channel is natural earth, broken shale, and limestone, with a moderate cover of brush and small trees. Minor erosion of the bottom and left side of the spillway channel has occurred.

d. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir. A minor amount of siltation has occurred at the upstream end of the reservoir.

e. Downstream Channel. Open channel comprised of broken limestone and shale located at the left end of the dam embankment.

3.2 EVALUATION

None of the conditions observed are significant enough to indicate a need for immediate remedial action. The inspection team observed no deficiencies at the dam at the time of the inspection.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, withdrawals to the water treatment plant, and capacity of the uncontrolled spillway. During periods of little or no rain and heavy water usage, water is pumped into Drexel Lake in a 6-inch cast iron pipe from a lake located approximately 3/4 mile south of the dam. Water is withdrawn from Drexel Lake by a 3-inch pipe which connects to the treatment plant near the downstream face of the dam.

4.2 MAINTENANCE OF DAM

Trees and brush are regularly removed from the embankment. Grass on or near the embankment is cut periodically as necessary.

4.3 MAINTENANCE OF OPERATING FACILITIES

Maintenance of the inflow pipe and the withdrawal pipe is performed as needed for water supply operations.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

4.5 EVALUATION

At the time of the inspection no deficiencies were observed. The dam appears to be in good condition and well maintained.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data pertaining to hydrology and hydraulics were unavailable.

b. Experience Data. The drainage area and lake surface area are developed from USGS Drexel and Freeman Quadrangle Maps. The spillway and dam layouts are from surveys made during the inspection. The soils of the watershed consist of the Summit Silt Loam soil series. This soil is an upland residual soil developed from weathering of shales and thin limestones of Pennsylvanian age. The soil consists of a mixture of sand, silt, clay, and organic matter. The near-surface soil is predominantly clayey silt; the deeper soil is predominantly silty clay. For engineering purposes, the near surface soil is classified ML-CL, and the deeper soil is classified as CL. The lower permeability of the deeper soil may cause increased runoff during long periods of high precipitation. Soils are generally thicker on the uplands and in the valleys and thinner on valley slopes.

c. Visual Observations.

(1) The spillway is in good condition.

(2) The intake structure and 3-inch line to the water treatment plant could be used to drawdown the pool. Because of the minor capacity of the pipeline, drawdown of the pool would require a considerably long time.

(3) A spillway and exit channel are located near the left abutment. Spillway discharges are not anticipated to endanger the integrity of the dam.

d. Overtopping Potential. The spillway will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway will pass 20 percent of the probable maximum flood without overtopping the dam. This flood is greater than the 100-year flood. The distribution for the 100-year frequency rainfall was supplied by the St. Louis District, Corps of Engineers. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Based on the amount of water impounded by the dam and the hazard classification, the spillway should be designed to pass 50 percent of the maximum probable flood. The portion of the estimated peak discharge

of the probable maximum flood overtopping the dam would be 14,650 cfs of the total discharge from the reservoir of 22,960 cfs. The estimated duration of overtopping is 6.7 hours with a maximum height of 4.6 feet. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 5,520 cfs of the total discharge of the reservoir of 10,530 cfs with a maximum depth over the dam of 2.4 feet. The estimated duration of overtopping is 4.3 hours. The riprap on the upstream and downstream slopes of the dam will provide protection from erosion during overtopping. Failure of upstream water impoundments shown on the 1975 revised USGS map would not have a significant impact on the hydrologic or hydraulic analysis.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately 0.5 mile downstream of the dam. There are four dwellings and the water treatment plant for the City of Drexel which could be severely damaged and lives could be lost should failure of the dam occur.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Detailed seepage and stability analysis should be performed as required by the guidelines.

c. Operating Records. No operational records exist.

d. Post Construction Changes. No known post construction changes.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone.

The seismic stability of an earth dam is dependent upon a number of factors: The important factors being embankment and foundation material classification and shear strengths; abutment materials, conditions, and strength; embankment zoning; and embankment geometry. Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. No deficiencies were observed by the inspection team during the visual inspection.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. However, seepage and stability analyses are needed to satisfy the requirements of the guidelines.

c. Urgency. It is the opinion of the inspection team that a program should be developed to implement measures recommended in paragraph 7.2b.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam or identify any serious dangers that would require a Phase II investigation.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment was not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The present spillway has the capacity to pass 20 percent of the probable maximum flood without overtopping the dam. In order to pass 50 percent of the probable maximum flood as required by the Recommended Guidelines, the spillway size and/or height of dam would need to be increased.

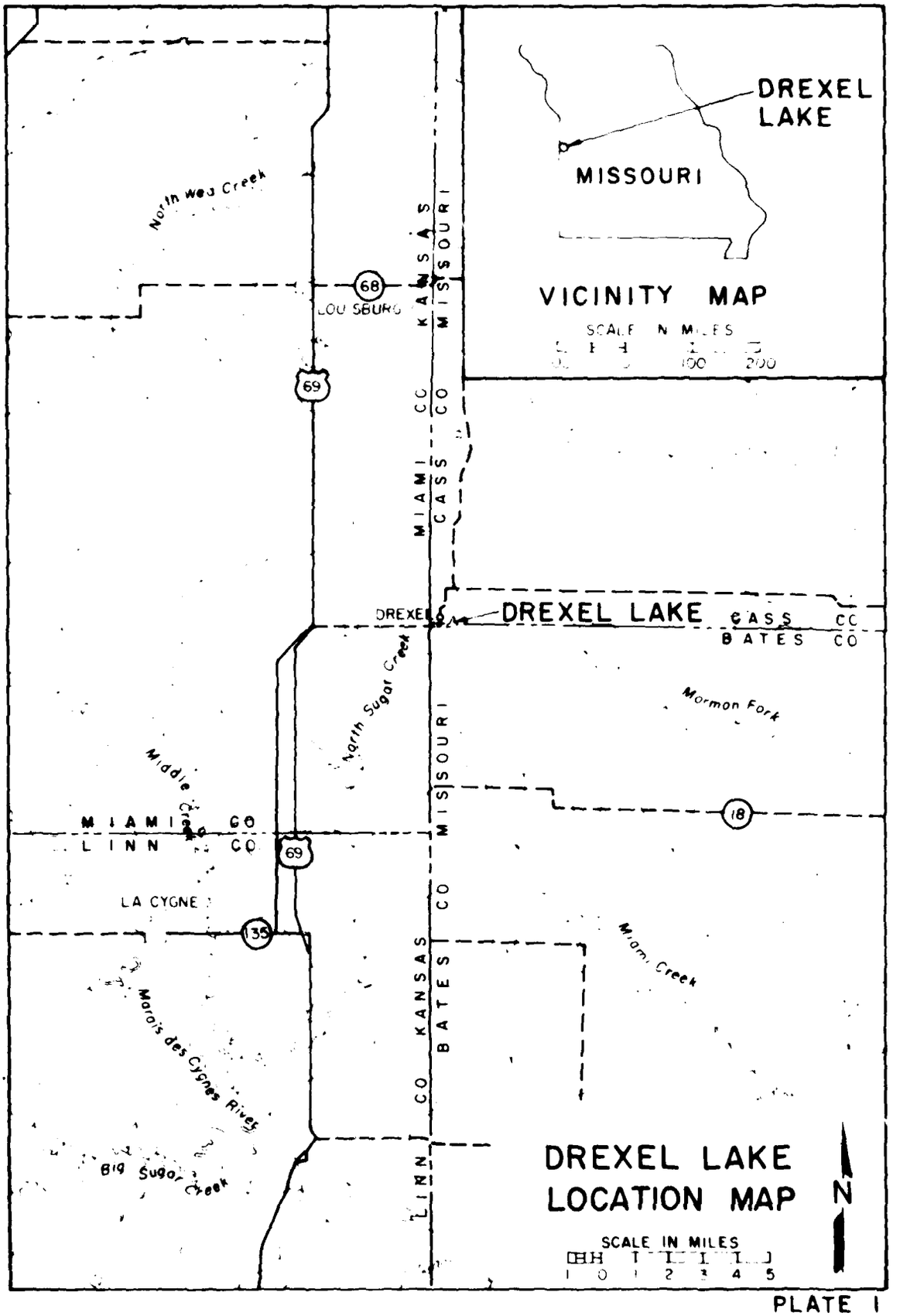
b. O&M Maintenance and Procedures. The following O&M maintenance and procedures are recommended:

(1) Check the downstream face of the dam periodically for seepage and stability problems. If seepage flows are observed or sloughing on the downstream embankment slope is noted, the dam should immediately be inspected and the condition evaluated by an engineer experienced in design and construction of earthen dams.

(2) The present regular maintenance program should be continued to control the growth of brush and grass on the dam embankment.

(3) Seepage and stability analysis should be performed by a professional engineer experienced in the design and construction of dams to satisfy the requirements of the guidelines.

(4) A detailed inspection of the dam should be made periodically by an engineer experienced in design and construction of dams. More frequent inspections may be required if deficiencies are observed.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DREXEL
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BATES CO
North Sugar Creek
Mormon Fork
Middle Creek
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LINN CO
Marais des Cygnes River
Big Sugar Creek
Miami Creek
DREXEL LAKE
LOCATION MAP
N
SCALE IN MILES
0 1 2 3 4 5

PLATE 1

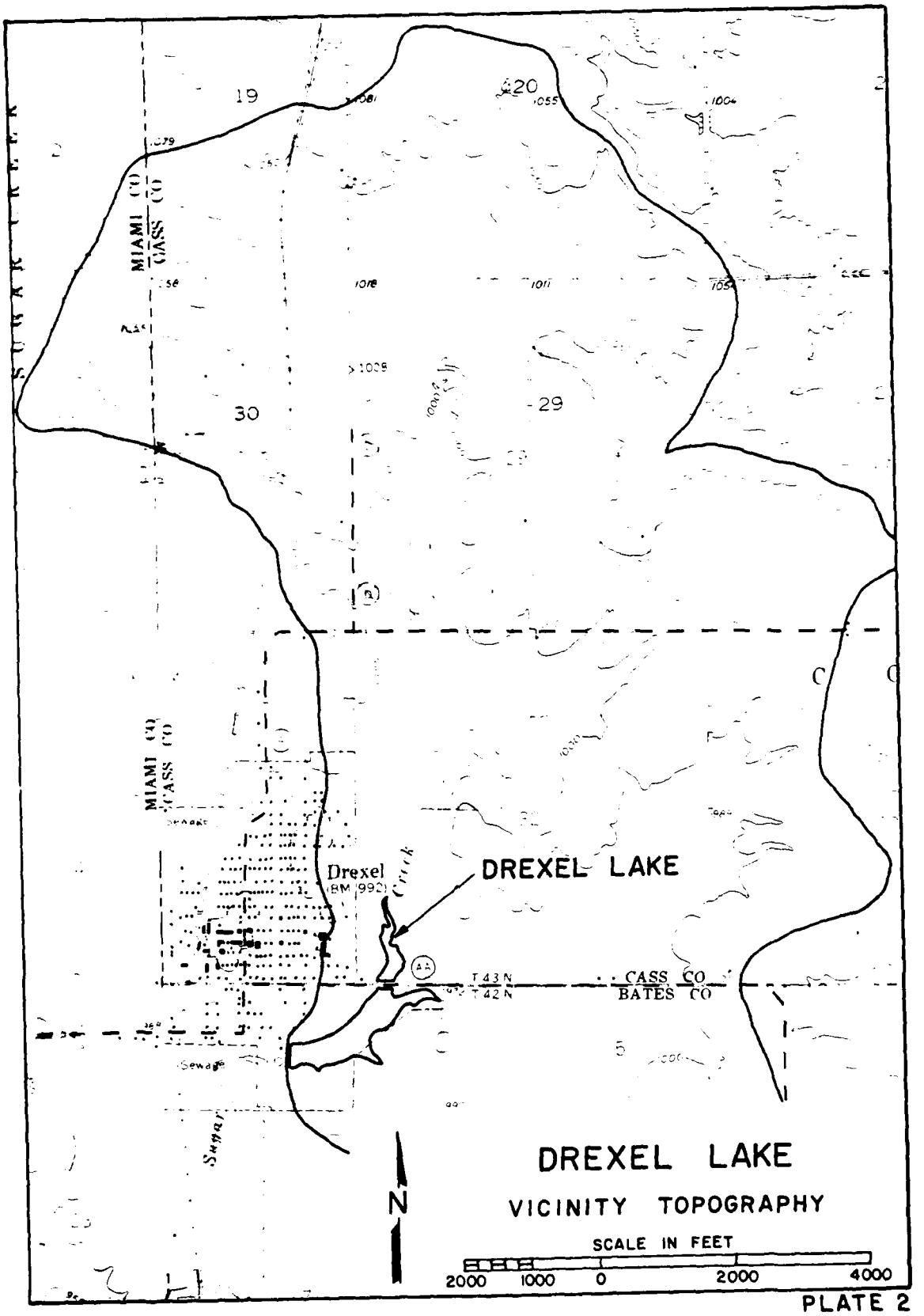
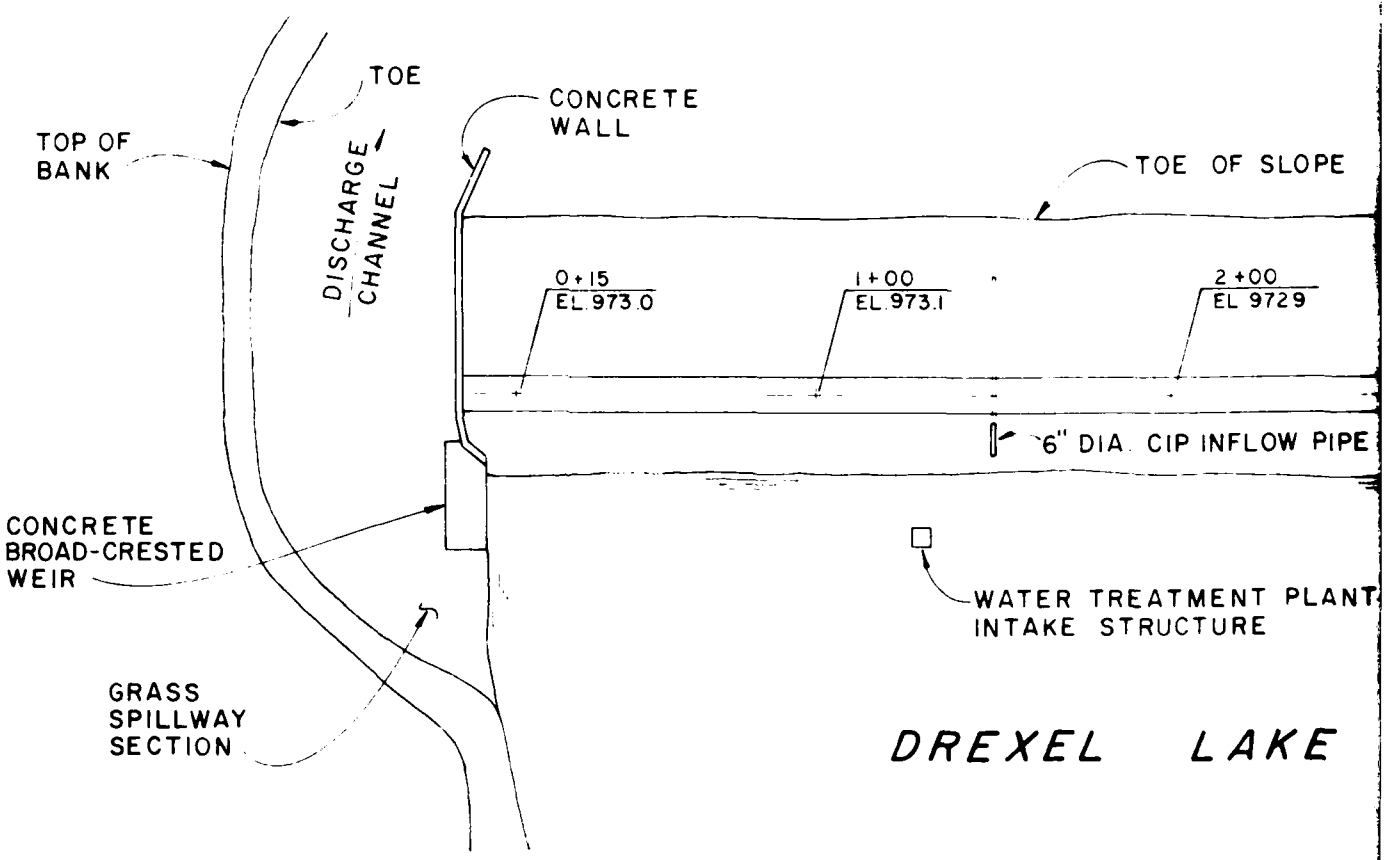
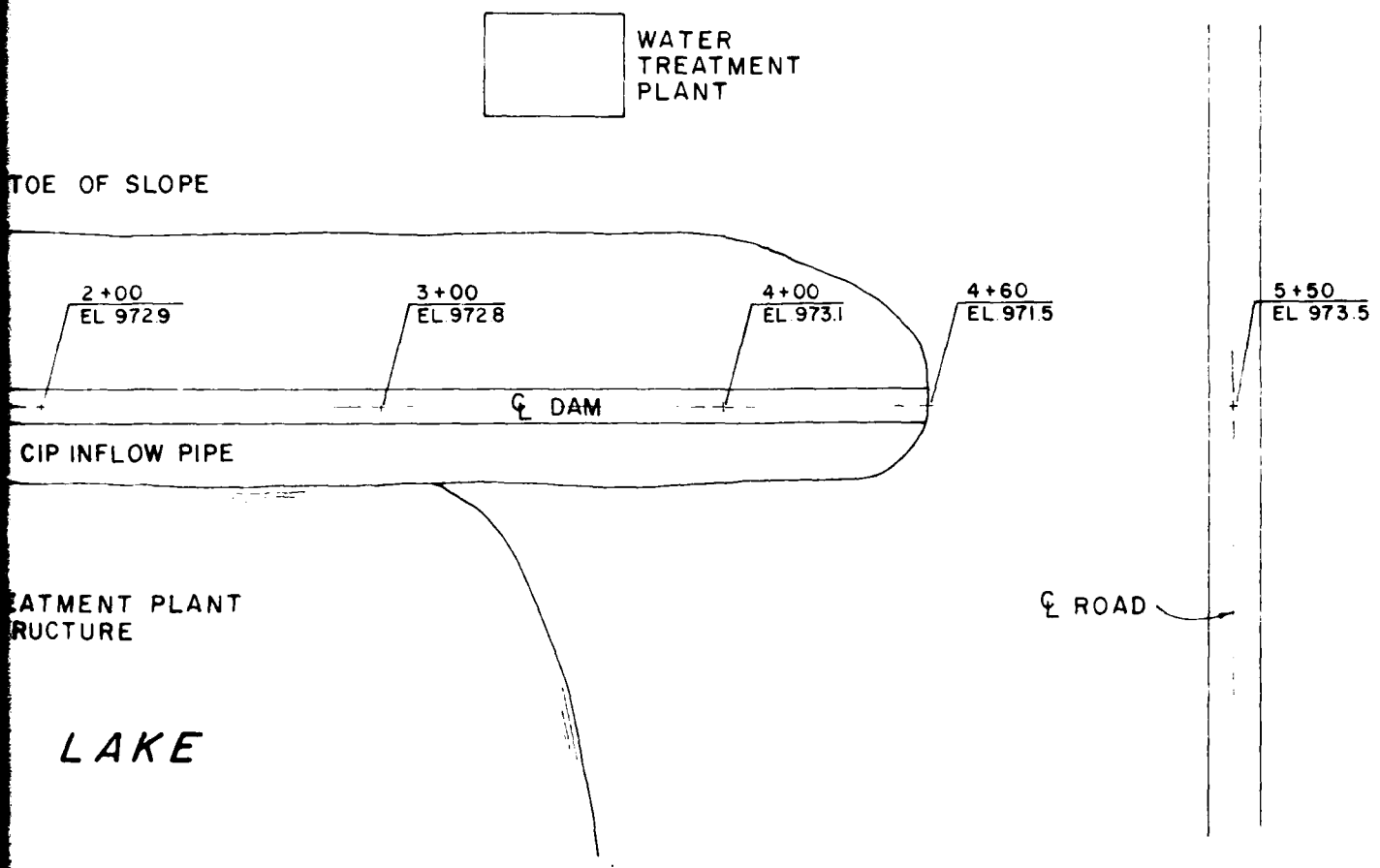

19
20
30
29
MIAMI (T)
CASS CO
MIAMI (T)
CASS CO
Drexel
(BM 992)
DREXEL LAKE
T 43 N
T 42 N
CASS CO
BATES CO
Sewage
Sewage
N
DREXEL LAKE
VICINITY TOPOGRAPHY
SCALE IN FEET
2000 1000 0 2000 4000

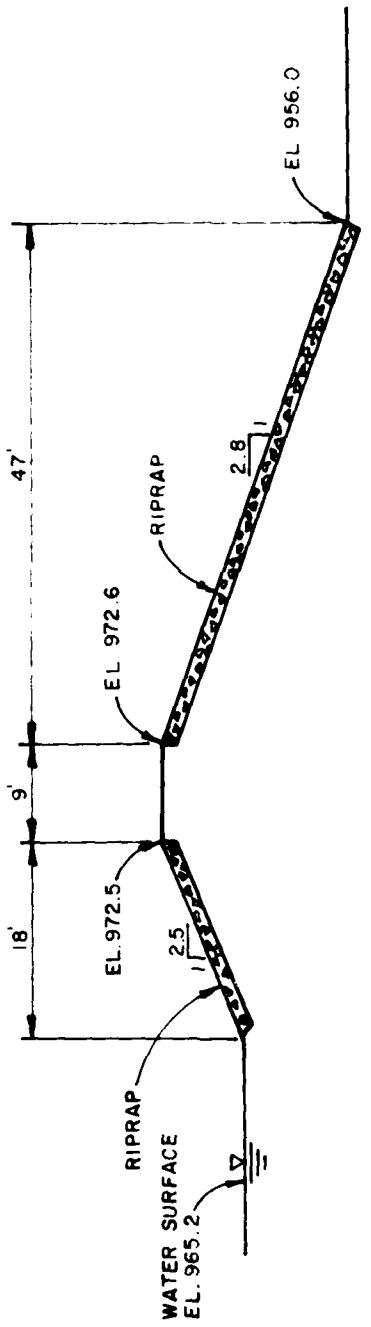
PLATE 2


TOE
CONCRETE WALL
TOP OF BANK
DISCHARGE CHANNEL
TOE OF SLOPE
0+15
EL. 973.0
1+00
EL. 973.1
2+00
EL. 9729
6" DIA. CIP INFLOW PIPE
CONCRETE BROAD-CRESTED WEIR
WATER TREATMENT PLANT INTAKE STRUCTURE
GRASS SPILLWAY SECTION
DREXEL LAKE



DREXEL LAKE PLAN

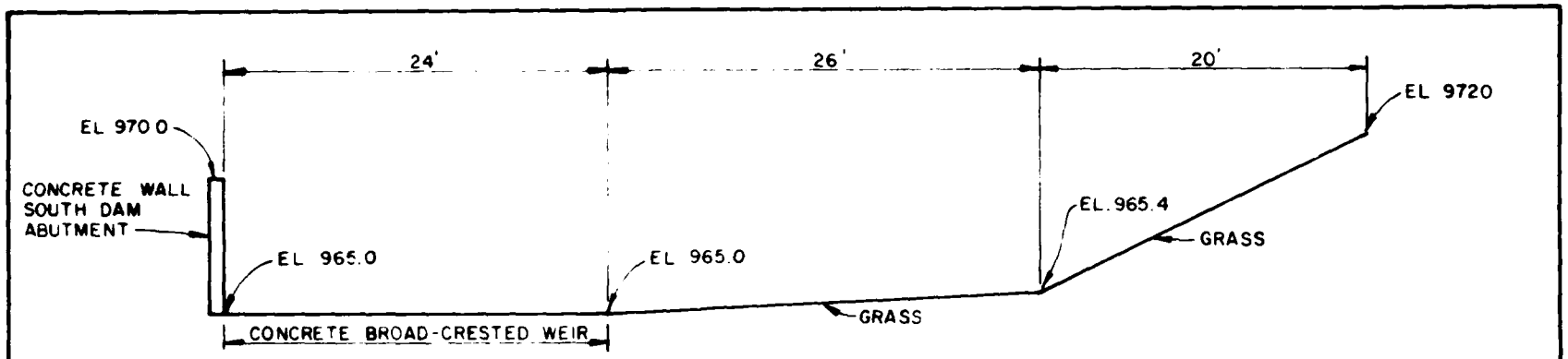
PLATE 3



DREXEL LAKE
TYPICAL SECTION

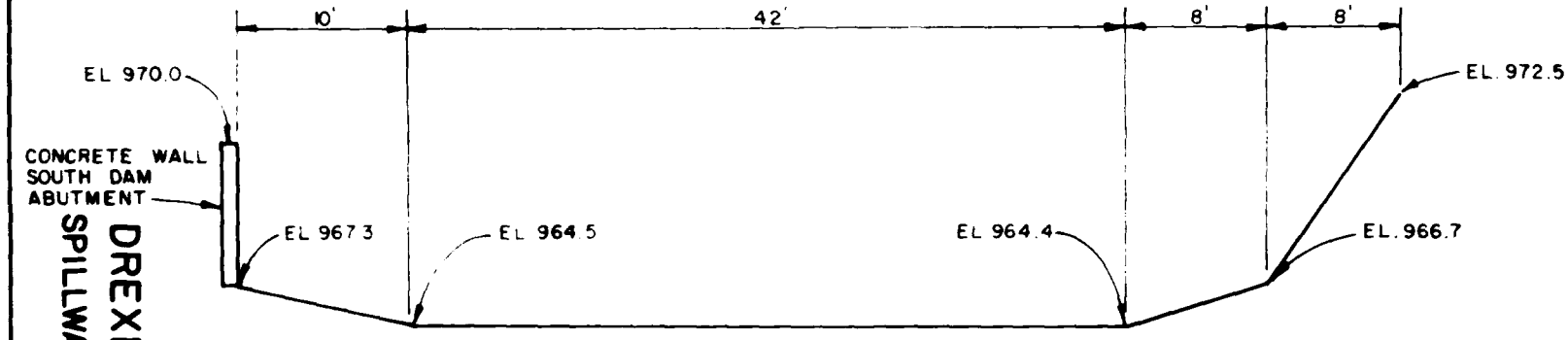
DREXEL LAKE
TYPICAL SECTION

PLATE 4



SPILLWAY SECTION

LOOKING UPSTREAM



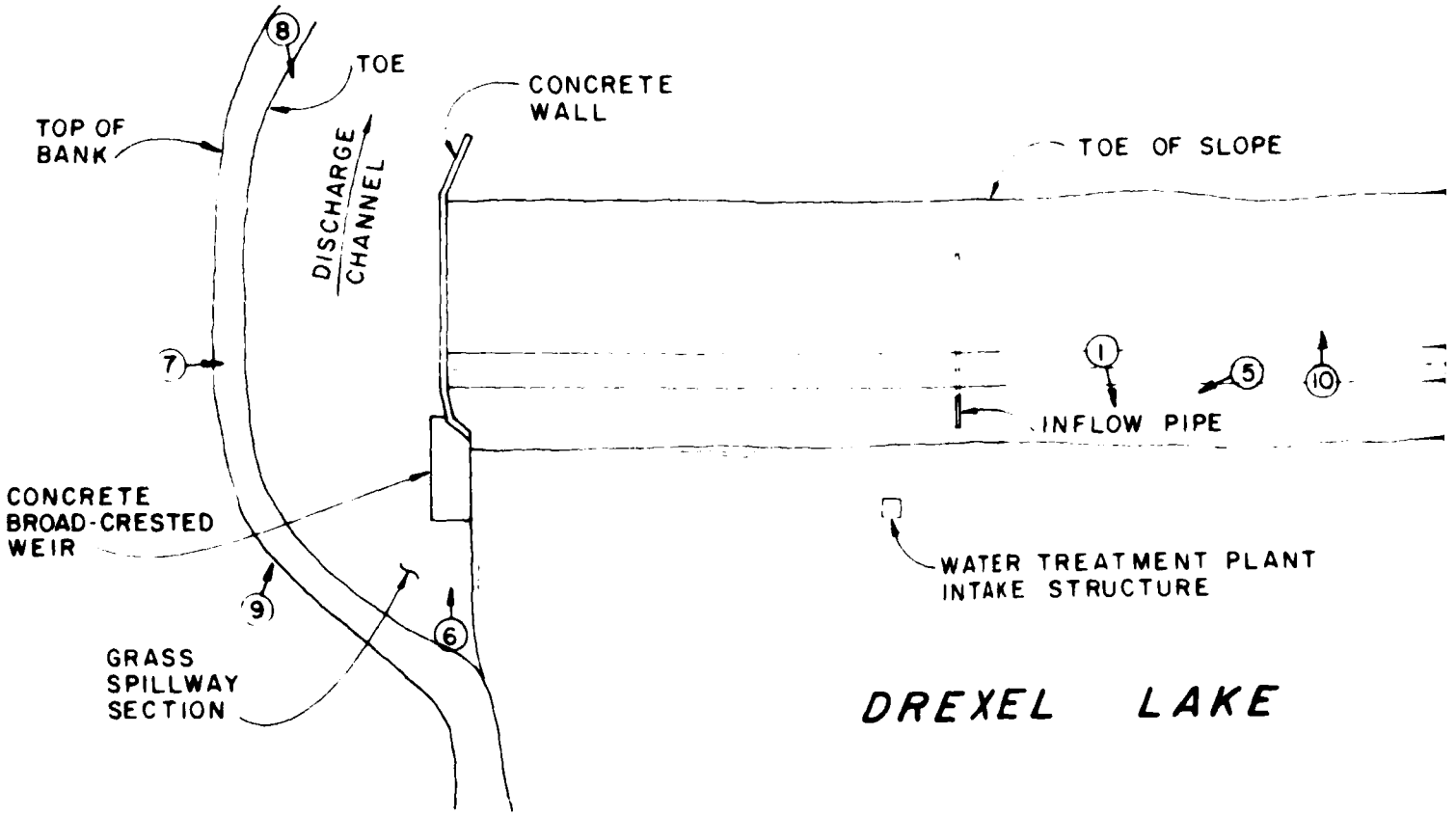
DISCHARGE CHANNEL SECTION AT CENTERLINE OF DAM

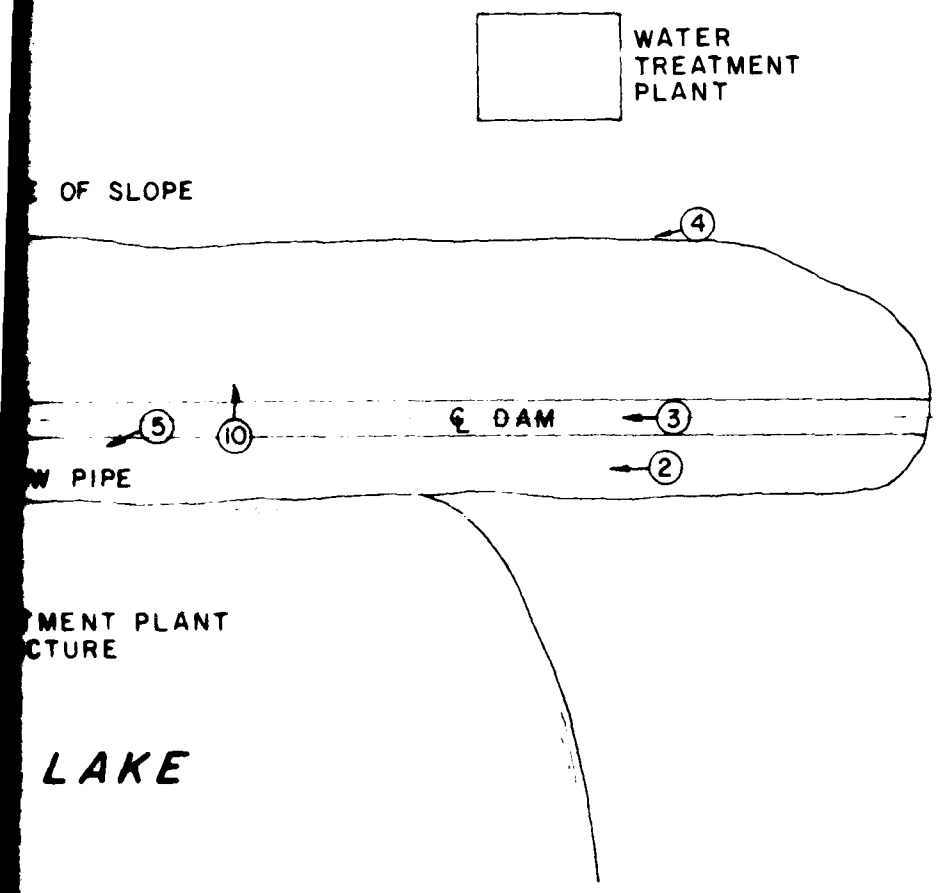
LOOKING UPSTREAM

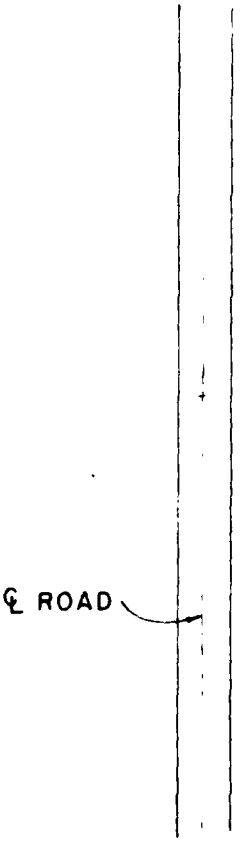
DREXEL LAKE

SPILLWAY SECTIONS

PLATE 5


8
TOE
TOP OF BANK
DISCHARGE CHANNEL
CONCRETE WALL
TOE OF SLOPE
7
1
5
10
INFLOW PIPE
CONCRETE BROAD-CRESTED WEIR
WATER TREATMENT PLANT INTAKE STRUCTURE
9
6
GRASS SPILLWAY SECTION
DREXEL LAKE





LEGEND

→(1) PHOTO LOCATION AND DIRECTION

N

DREXEL LAKE PHOTO INDEX

PLATE 6

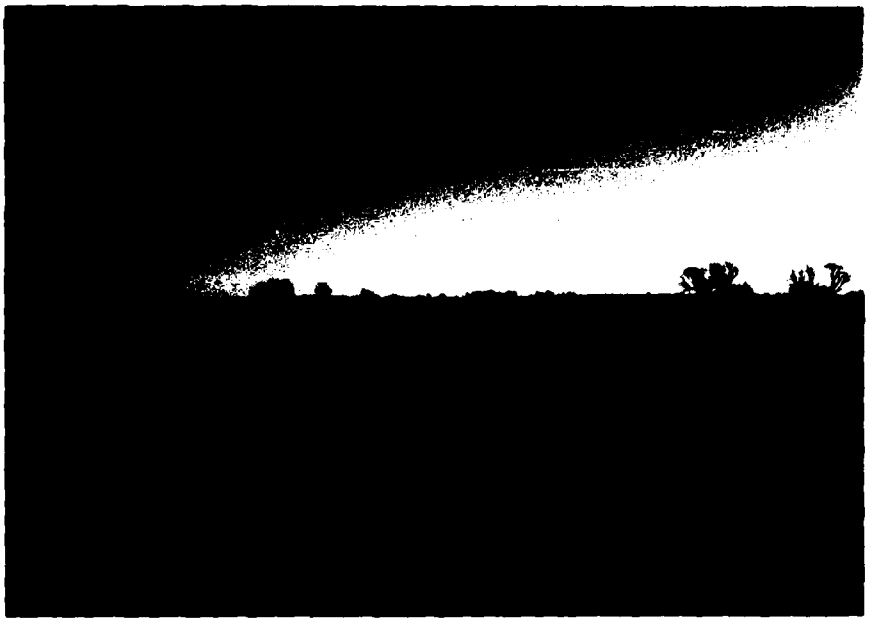


PHOTO 1: VIEW OF LAKE FROM DAM

PHOTO 2: UPSTREAM FACE OF DAM LOOKING SOUTH

PHOTO 3: CREST OF DAM LOOKING SOUTH

PHOTO 4: DOWNSTREAM FACE OF DAM LOOKING SOUTH

PHOTO 5: INTAKE STRUCTURE AND INFLOW PIPE

PHOTO 6: SPILLWAY CREST

PHOTO 7: SOUTH DAM ABUTMENT AND SPILLWAY DISCHARGE CHANNEL

PHOTO 8: SPILLWAY DISCHARGE CHANNEL LOOKING UPSTREAM

PHOTO 9: SPILLWAY DISCHARGE CHANNEL LOOKING DOWNSTREAM

PHOTO 10: DAMAGE ZONE LOOKING DOWNSTREAM FROM DAM

APPENDIX A

HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs, and hydrologic inputs are as follows:

a. Twenty-four hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 25.1
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile, rainfall	- 130%
10 square miles, 48 hour percent of 24 hour 200 square mile, rainfa.l	- 140%

b. Drainage area = 2,920 acres.

c. Time of concentration: $Tc = (11.9 \times L^3/H)^{0.385}$ = 1.37 hours = 83 minutes (L = length of longest watercourse in miles, H = elevation difference in feet) (2)

d. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 89 and antecedent moisture condition III. The hydrologic soil group in the basin was type C.

2. Spillway release rates are based on the broad-crested weir equation.

Broad-crested weir equation:

$Q = CLH^{1.5}$ (for concrete section, C = 2.64 to 2.68, L = 24.0 feet; for grass section C = 2.63, L = 26 to 46 feet; H is the head on weir).

Discharge rates over the top of the dam are also based on the broad-crested weir equation:

$Q = CLH^{1.5}$ (C = 2.7, L = 460 feet).

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour above normal pool. The storage between two elevations was computed by multiplying the average of the areas at the two elevations by the elevation difference. The summation of these increments below a given elevation is the storage below that level.

4. Floods are routed through the spillway using HEC-1, modified Puls to determine the capability of the spillway.

(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Modification September 1978, Davis, California.

(2) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.

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**********
FLOOD HYDROGRAP'  ' 'AGE (HEC-1)
DAM SAFETY VERS.       JULY 1978
  LAST MODIFICATION  25 SEP 78
**********
    1                 A1       MISSOURI DAM INSPECTIONS - DREXEL LAKE
    2                 A2       PMF ROUTING FOR DREXEL LAKE DAM
    3                 A3       DRAINAGE AREA = 2920 ACRES
    4                 B     288        0       10        0        0        0        0        0        0        0
    5                 B1      5
    6                 J       1        9        1
    7                 J1.05    .1       .15      .2       .25      .3       .4       .5      1.
    8                 K       0   HEAD                              1        3        1
    9                 K1       DREXEL LAKE 48 HOUR PROBABLE MAXIMUM FLOOD INFLOW HYDROGRAPH
   10                 M       1       24.56                          1.
   11                 P        25.1     101.     120.     130.     140.
   12                 T                                                                -1      -89
   13                 W2       0.83
   14                 X                         1
   15                 K       1  DAM                                 1                 1
   16                 K1       ROUTING PROBABLE MAXIMUM FLOOD THROUGH DREXEL LAKE
   17                 Y                                      1        1
   18                 Y1      1                                                -965.            -1
   19                 Y4965.   966.     967.     969.     970.     972.     973.     975.     977.     980.
   20                 Y50.     105.     350.     1110.    1590.    2815.    3730.    9380.    19355.   38000.
   21                 $S0.     195.     390.     1365.
   22                 $E965.   970.     972.8    980.
   23                 $$965.
   24                 $D972.8
   25                 K       99
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1 .05	RATIO 2 .10	RATIO 3 .15	RATIO 4 .20	RATIO 5 .25	RATIO 6 .30	RATIO 7 .40	RATIO 8 .50	RATIO 9 1.00
HYDROGRAPH AT	HEAD	4.56	1	1224.	2448.	3672.	4895.	6119.	7343.	9791.	12239.	24477.
		(11.81)	(	34.66)(	69.31)(	103.97)(	138.62)(	173.28)(	207.94)(	277.25)(	346.56)(	693.12)
ROUTED TO	DAM	4.56	1	821.	1723.	2496.	3437.	4564.	5769.	8055.	10526.	22957.
		(11.81)	(	23.25)(	48.79)(	70.69)(	97.33)(	129.23)(	163.37)(	228.10)(	298.06)(	650.06)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	965.00	965.00	972.80
STORAGE	0.	0.	390.
OUTFLOW	0.	0.	3547.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	968.24	0.00	126.	821.	0.00	41.17	0.00
.10	970.22	0.00	210.	1725.	0.00	41.00	0.00
.15	971.48	0.00	298.	2496.	0.00	41.17	0.00
.20	972.68	0.00	382.	3437.	0.00	41.00	0.00
.25	973.30	.50	457.	4564.	1.67	41.00	0.00
.30	973.72	.92	515.	5769.	2.50	40.83	0.00
.40	974.53	1.73	624.	8055.	3.50	40.83	0.00
.50	975.23	2.43	719.	10526.	4.33	40.83	0.00
1.00	977.37	4.57	1009.	22957.	6.67	40.67	0.00